"... a first pressure sensor that is formed substantially at said ink well and configured to detect pressure waves induced by a firing of said ink expulsion mechanism."

Since this feature is not disclosed by Isayama, Applicant respectfully submits that Isayama does not anticipate Claim 1 or its dependents.

Claim 4 was rejected under 35 USC §102(b) as being anticipated by Tanaka. Claim 4 recites sensor placement in an individual ink well, similar to 61 of Tanaka. Tanaka discloses a sensor (for "ink out" measurement) that is placed in the main reservoir 64 (see Fig. 4). Thus, Tanaka does not disclose the claimed location or function of the sensor of claim 4 and thus does not anticipate claim 4.

Claims 5,8 and 13-14 are rejected under 35 USC 103 as being unpatentable over Widder in view of Tanaka. Claims 5 and 8 depend from claim 1 which includes the above mentioned limitation that the sensor is provided substantially at the ink well. Widder in view of Tanaka does not disclose or suggest this limitation. Claims 13-14 which depend from claim 10 are allowable due to their dependence from claim 10 as amended, which is now discussed.

Claims 10-12 are rejected under 35 USC §102(b) as being anticipated by Tanaka. In Tanaka, the sensor that detects whether a nozzle is clogged or not is sensor 38 (see Fig. 3). This sensor is not provided on the same printhead substrate as the ink expulsion mechanism, but rather is provided external to the printhead substrate. Claim 10 as amended recites "... a substrate ... and a sensor mechanism *formed on said substrate* that is capable of *detecting signals indicative of when said nozzle is clogged*" (emphasis added).

Claims 17-19 were rejected under 35 USC §103 as being unpatentably over Scardovi in view of Yamamoto and further in view of Hubbard. Claim 17 as amended includes the limitation of

"... detecting within said print head a firing quality related characteristic of a resultant pressure wave generated by said attempt to expel said volume of ink through said nozzle."

Scardovi and Yamamoto are directed towards increasing the velocity of printing in piezo-electric actuated printers. Yamamoto at Col. 6, lines 43-57, teaches switching and drive circuitry for (relatively) rapid firing of a piezo-electric transducer, but does not disclosed or suggest sensing or detection of a resultant pressure wave to determine firing quality. Neither Yamamoto nor Scardovi disclose or suggest, individually or in combination, this feature.

Hubbard does not disclose detection of a pressure wave, but rather use of a photodetector to detect reflected *light* intensity *external* to the print head. Thus, the combination of Scardovi, Yamamoto and Hubbard do not disclose or suggest the "detecting within said print head a firing quality related characteristic of a resultant pressure wave generated by said attempt to expel said volume of ink through said nozzle."

New claim 28 is objected to claim 20 with the limitations of the base claim.

Other claims herein have been amended for clarity.

In view of the foregoing Amendments and these Remarks, Applicant respectfully submits that Claims 1-28 are now in condition for allowance and early notification of same is respectfully requested. Should the Examiner believe that a telephone conference would help further the prosecution of this case, the Examiner is requested to contact the undersigned at the listed telephone number.

The Assistant Commissioner is hereby authorized to charge underpayment of any fees (including any filing fees under 37 C.F.R. §1.16 for additional claims and any patent application processing fees under 37 C.F.R. §1.17 including any fee for extension of time) associated with this communication or credit

any overpayment to Deposit Account No. 01-0272. A duplicate copy of this authorization is enclosed.

Respectfully Submitted
on behalf of Applicant(s),

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Separate, marked-up version of amended paragraphs (§1.121(b)):

Page 3, lines 13-15:

Fig. 5 is a graph [of] illustrating the pressure on an expulsion mechanism surface versus time for a clogged nozzle firing and an unclogged nozzle firing [is shown].

Pages 4-5, lines 10-6, respectively:

Assuming that ink expulsion mechanism 14 is a thermally actuated device such as a resistor, an ink drop is expelled by essentially boiling a drop of ink through nozzle 31. During formation and collapse of a boiling ink bubble, a series of acoustic pressure waves 26 (hereinafter referred to as "pressure waves") are produced. These waves propagate through the components of the print head, including primarily the substrate and ink well. {new paragraph}

In the substrate (and conventional thin film layers formed thereon), both longitudinal and shear waves are produced. Longitudinal waves can be detected by an interdigitated piezoelectric pressure wave transducer 50 or the like which is described in more detail with reference to Figs. 3 and 4. In the ink well [24], longitudinal pressure waves are produced. These waves can be detected with a piezoelectric acoustic pressure wave transducer 40 which is described in more detail with reference to Fig. 2. {new paragraph}

For purposes of the present discussion, the term "interdigitated transducer" will be used for the interdigitated piezoelectric pressure wave transducer and the term "acoustic transducer" will be used for the piezoelectric acoustic pressure wave transducer. While both an acoustic transducer and an interdigitated transducer are described as being provided on substrate 12, it should be recognized that they need not be provided together because either transducer is capable of

sufficiently detecting pressure waves. The provision of both provides redundancy.

Pages 5-6, lines 18-9, respectively:

Referring to Fig. 2, a side view of an acoustic transducer in accordance with the present invention is shown. Fig. 2 illustrates the acoustic transducer of Fig. 1 in more detail. Fig. 2 illustrates substrate 12 on which the following layers are formed: an insulation layer 21, a conductive coupling layer 41, piezoelectric material 42, a first and a second signal conductive layer 44,45, a passivation layer 47 and a surface coat layer 48. In a preferred embodiment, these layers are made of the following or a like material: insulation layer 21 is silicon dioxide (SiO_2), conductive layer 41 is tantalum aluminum (TaAl), piezoelectric material 42 is aluminum nitride (AlN), first and second conductive layers or traces 44,45 are aluminum (Al), passivation layer 47 includes a first layer of silicon nitride (Si_3N_4) and a second layer of silicon carbide (SiC), and coating layer 48 [layer] is tantalum (Ta). It should be recognized that the arrangement and composition of these layers may be altered in a manner consistent with device fabrication techniques without deviating from the present invention. It should also be recognized that other piezoelectric material such as zinc oxide (ZnO) or PZT may be used and that other types of suitable pressure sensors may be used.

Page 6, lines 10-17:

The first and second conductive layers 44,45 form conductors for reading a voltage generated by piezoelectric material 42 in response to an incident pressure wave. A pressure wave traveling through the ink well compresses the thin film stack, resulting in a mechanical strain in the thin film layers. In the piezoelectric layer, this strain produces a measurable electric charge across the two conductors.

Page 7, lines 3-21:

Referring to Fig. 4, a plan view of an arrangement of acoustic transducers and interdigitated transducers in a print head in accordance with the present invention is shown. Fig. 4 illustrates substrate 12, a plurality of ink expulsion mechanisms 14, barrier layer 20, ink well 24, a plurality of acoustic transducers 40 and a plurality of interdigitated transducers 50. Orifice plate 30 would be placed over the arrangement of Fig. 4 with nozzles aligned with the ink expulsion mechanisms 14. It should be recognized that the transducer arrangement disclosed in Fig. 4 is representative and provided for pedagogical purposes. The ink expulsion mechanisms, ink well and the size, number and arrangement of transducers may be modified from that of Fig. 4 without departing from the present invention. Furthermore, it should be recognized that although the interdigitated transducers are shown in the ink well, since they detect pressure waves in the substrate they may be placed anywhere on the substrate including under the barrier layer.

Separate, marked-up version of amended claims (§1.121(c)):

1 (amended). A print head apparatus, comprising:

a substrate;

an ink expulsion mechanism provided on said substrate;

an ink well defined proximate said ink expulsion mechanism and a nozzle formed as an egress from said ink well; and

a first pressure sensor that is [capable of detecting a signal related to a firing of said ink expulsion mechanism] formed substantially at said ink well and configured to detect pressure waves induced by a firing of said ink expulsion mechanism.

4 (amended). The apparatus of claim 1, further comprising:

a barrier layer formed on said substrate;

a cover plate having a nozzle therein formed on said barrier layer and positioned such that said nozzle is aligned with said ink expulsion mechanism, said substrate, barrier and cover plate defining [an] said ink well; and

wherein said first sensor is provided at said ink well in such a manner as to detect pressure waves propagating in ink in said ink well caused by a firing of said ink expulsion mechanism.

10 (amended). A print head apparatus, comprising:

a substrate;

an ink expulsion mechanism formed on said substrate;

a cover plate spaced from said ink expulsion mechanism and having a nozzle formed therein, said nozzle being aligned with said ink expulsion mechanism; and

a sensor mechanism formed on said substrate that is capable of [determining] detecting signals indicative of when said nozzle is clogged.

11 (amended). The apparatus of claim 10, wherein said sensor mechanism is capable of [determining] detecting signals indicative of when said nozzle is unclogged.

12 (amended). The apparatus of claim 10, wherein said sensor mechanism is capable of [determining] detecting signals indicative of one or more of the group of conditions including dry-fire and no-fire conditions.

13 (amended). The apparatus of claim 10, wherein said sensor is a pressure wave sensor.

16 (amended). The apparatus of claim 10, [wherein] further comprising logic coupled to said sensor mechanism that is capable of [detecting] determining a magnitude and timing of a pressure wave generated by a firing of said ink expulsion mechanism.

17 (amended). A method of monitoring performance of a print head, comprising the steps of:

attempting expulsion of a volume of ink [from] through a nozzle of a print head;

detecting within said print head a firing quality related characteristic of a resultant pressure wave generated by said attempt to expel said volume of ink through said nozzle.

18 (amended). The method of claim 17, further comprising the step of [determing] determining from said detected characteristic a status of said attempted expulsion of said volume of ink.

19 (amended). The method of claim 17, wherein said detecting step includes the step of detecting the presence or [absense] absence of a resultant pressure wave.